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EXHIBIT B

A true and correct copy of specification and drawings for provisional application number 60/216,298 as filed.

SELF-GUYED STRUCTURES

INVENTOR: Dennis J. (Denny) Newland

U.S. CLASS: 52/646, 52/146.148

REFERENCES CITED: U.S. Patent Documents

5,688,604	11/1997	Matan et al	428/542.2
4,449,348	5/1984	Jacobs	52/648
4,207,715	6/1980	Kitrick	52/81
4,711,062	12/1987	Gwilliam et al	52/646
3,063,521	11/1962	Fuller	189-34

ABSTRACT

A series of static structures formed from a plurality of interconnected rigid compression members or struts and flexible tension members or guys (e.g. wire cables,chains or elastic cords). Each strut is in pure compression (i.e. no bending or twisting forces) and each guy is in pure tension. The struts are discontinuous in several embodiments of the invention, intersect at an internal or peripheral point in others, or radiate outwardly from an internal central point in still others. Three configurations of guy arrangements are described and claimed for each strut arrangement. Self-Guyed Structures (SGS's) can be utilized as a stand-alone module or modules can be combined by connecting them at any point on a strut or guy in a nested (overlapping) or an adjacently attached configuration to assemble composite SGS's. For certain given design parameters, SGS's can be made more material efficient and lighter than conventional structures. Aesthetically pleasing designs for applications where the structure is to be visible can be readily achieved.

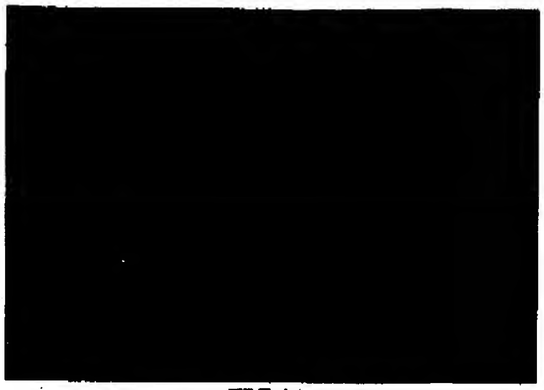

FIG.1A

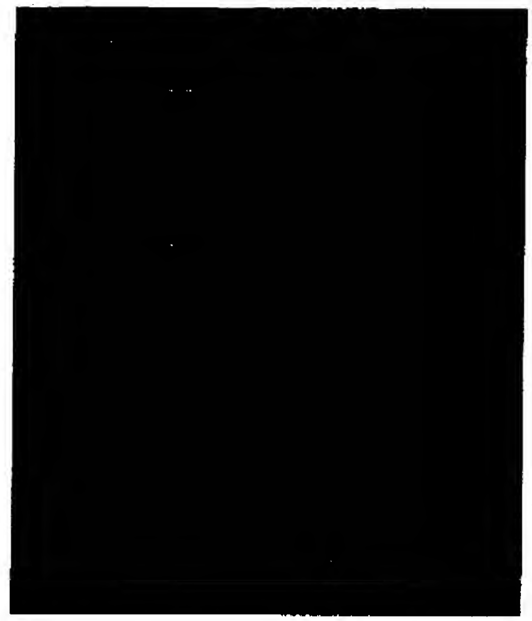

FIG.1B

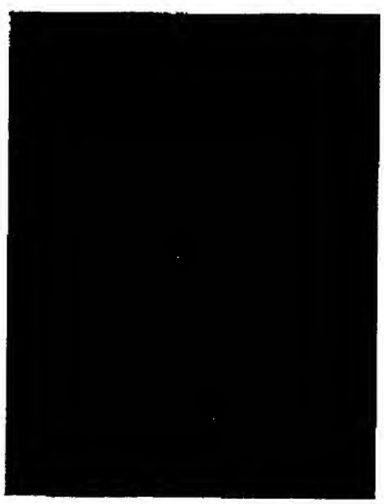

FIG.1C

FIG.1D

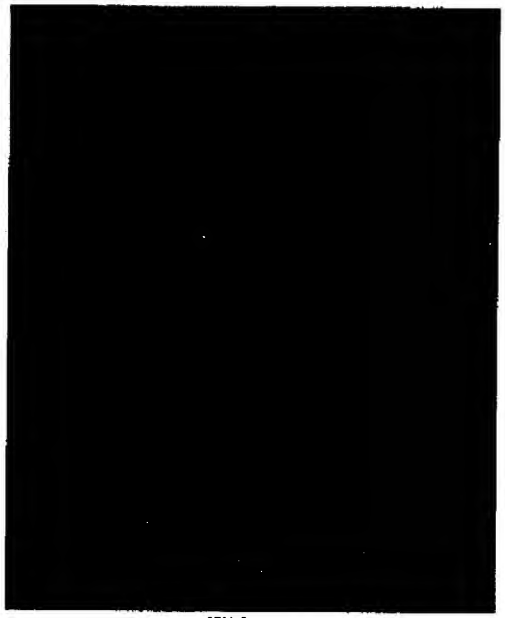

FIG.1E

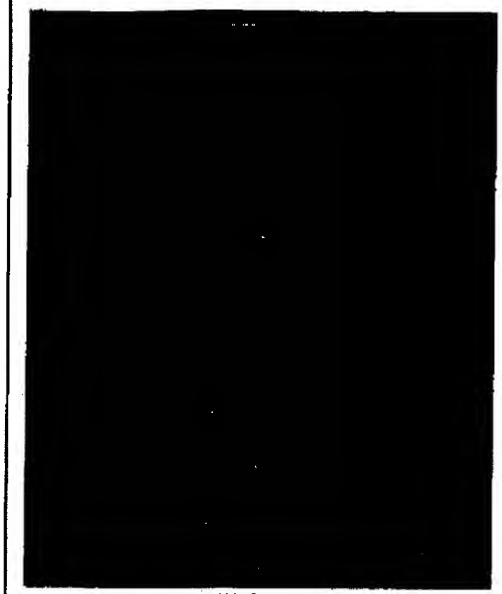

FIG.1F

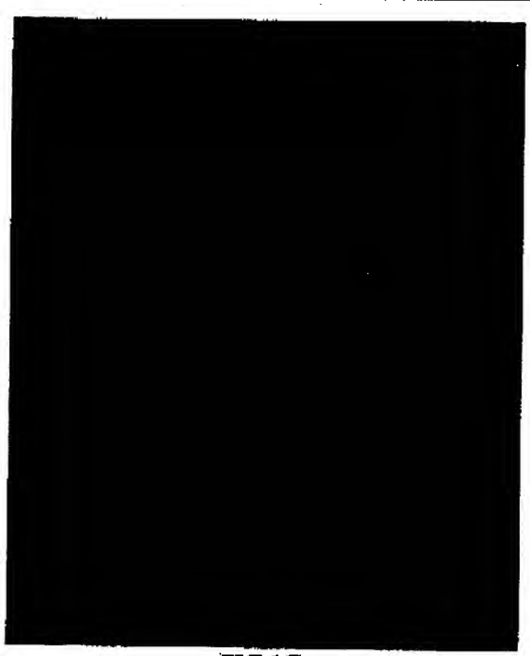

FIG.1G

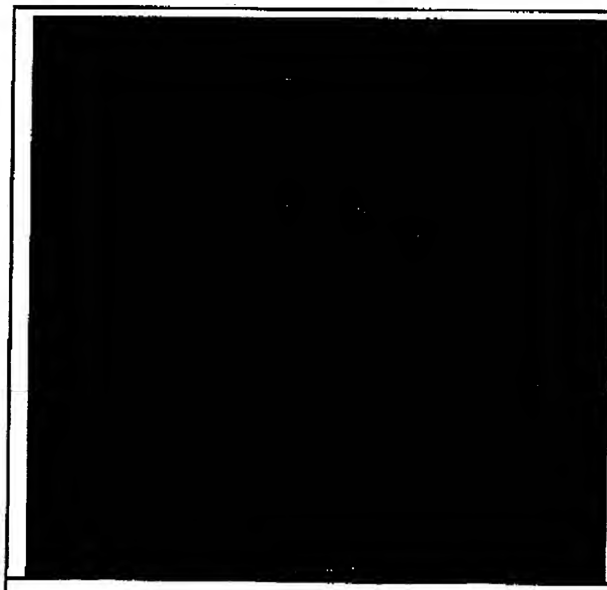

FIG.1H

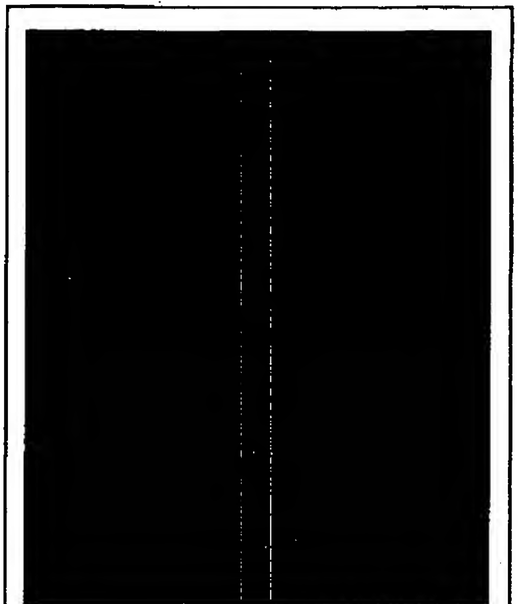

FIG.2A

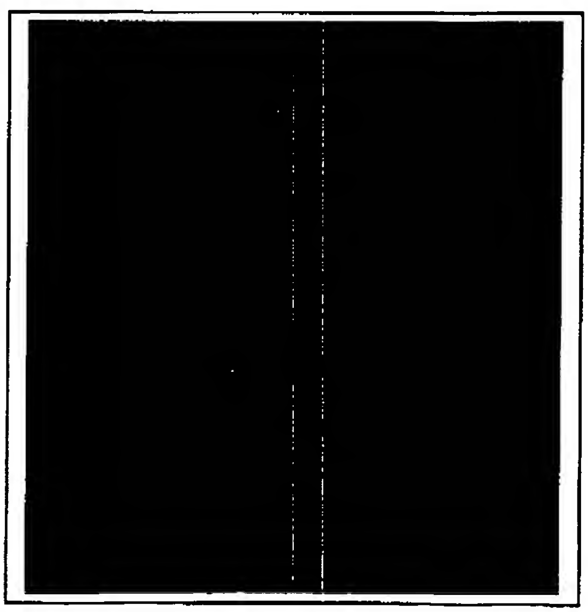

FIG.2B

FIG.3A

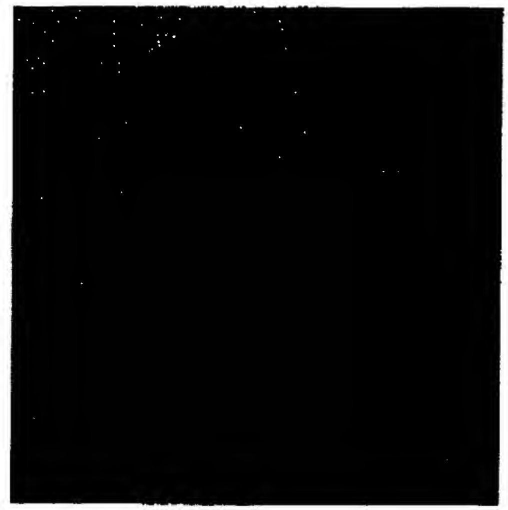

FIG.3B

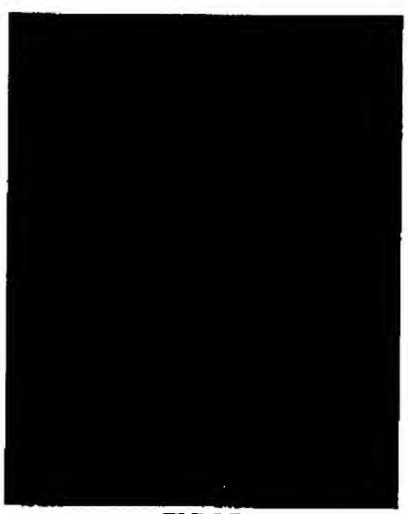

FIG.3C

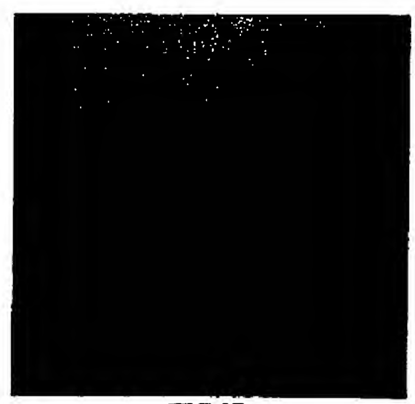

FIG.3D

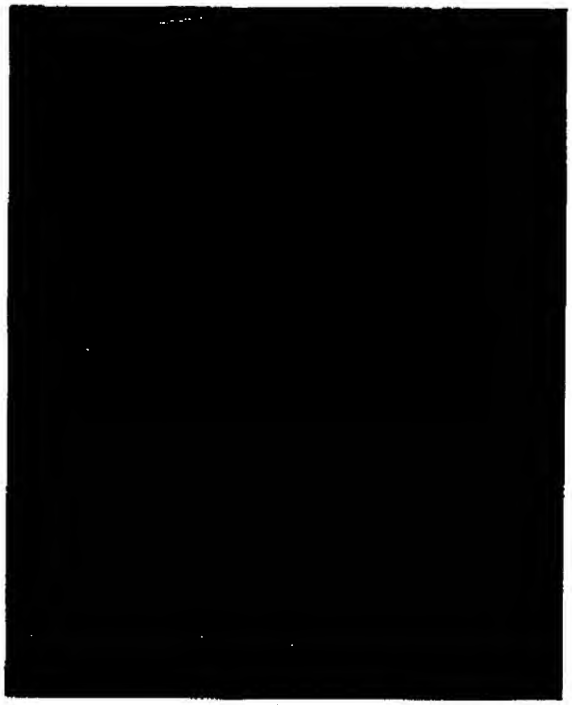

FIG.4A

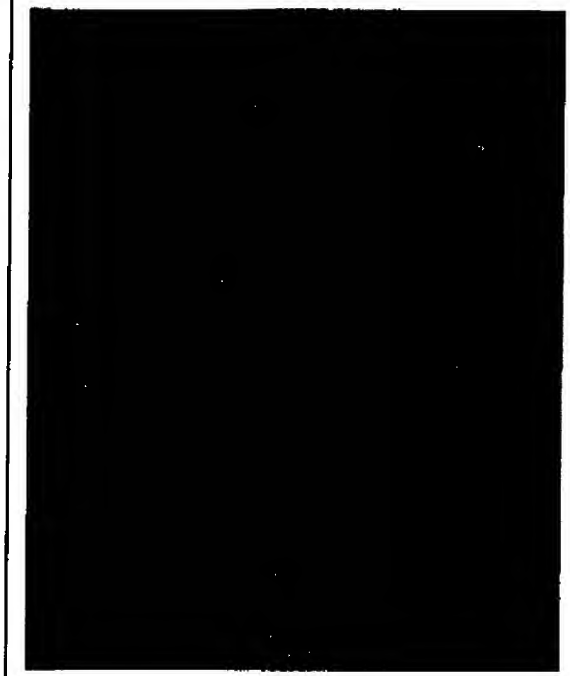

FIG.4B

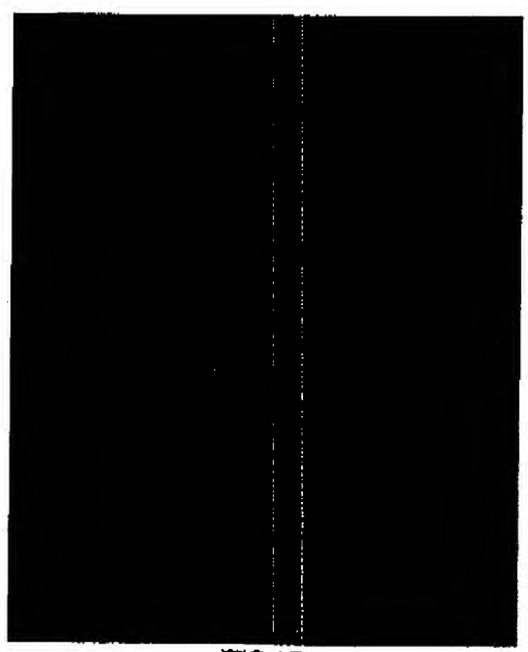

FIG.4C

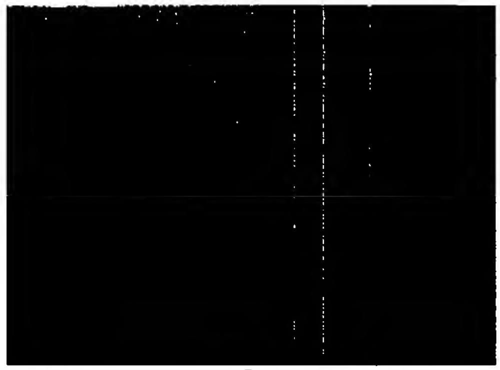

FIG.5A

FIG.5B

FIG.5C

BACKGROUND—FIELD OF INVENTION

This invention relates to three dimensional space defining and flexible guyed structures.

BACKGROUND—DISCUSSION OF PRIOR ART

The tensile-integrity (or tensegrity) sphere was introduced by Fuler (1962) in U.S. Patent No. 3,063,521 as he used what this invention classifies as multiple 3 discontinuous strut **HYPERBOLOID SGS's** with a circumferential configuration of tension members or guys to connect the strut ends in the "end-planes". This invention is an extension of Fuler's in that it includes two other guy configurations for the 3 discontinuous strut **HYPERBOLOID SGS** as well as including embodiments of four or more struts, each with three guy configurations.

The 6 discontinuous strut icosahedron with circumferential guys connecting the strut ends, thus forming the 20 faces of this polyhedron, was illustrated by Kitrick (1980) in U.S. Patent No. 4,207,715. This invention would classify this icosahedral tensile-integrity structure as a 6 discontinuous strut **PLANAR SGS.** This invention is an extension of this previous structure in that it includes two additional guy configurations for this 6 strut **PLANAR SGS** as well as including3,4,5 and 7 or more strut configurations, each with three guy configurations and configurations where the strut planes are not necessarily orthogonal.

Kitrick's patent also illustrated an octahedron with internal struts configured to radiate from an internal central point with a circumferential guy configuration connecting the strut ends, thus forming the eight faces of this polyhedron. Gwilliam et al also documented this octahedral arrangement of struts and guys in U.S. Patent No. 4,711,062 (1987). This invention would classify this configuration as a 3 strut **PLANAR SGS**. This invention is an extension of this previous structure in that it includes two other guy configurations for the 3 strut configuration as well as including 4,5 and 7 or more radial struts, each with three guy configurations and configurations where the strut angular separation is not necessarily equal.

Matan et al in U. S. Patent No. 5,688,604 (1997) and Jacobs in U.S. Patent No. 4,449,348 (1984) each devised structures composed of tension and compression members but in each case there was a twisting and/or a bending force on the compression members unlike this invention.

OBJECTS & ADVANTAGES

Accordingly it is the object of this invention to extend the art to include new configurations of struts and guys to create new static structures having the ability to meet

certain given design goals more economically and in more aesthetically pleasing arrangements.

Prior art has been limited to the configurations described above which have not enjoyed widespread use. It is an object of this invention to provide many additional configurations of the naturally material efficient structural design strategy of limiting structural elements to a purely compressional or a purely tensional load. By judicious choice of materials a wide range of strength, toughness, rigidity and/or flexibility and load response characteristics can be designed into these structures. By judicious combinations of **SGS's** either with other **SGS's** or with traditional structures, redundancy and failure tolerant designs can be achieved. Attractive and interesting as well as functional designs for applications where the structure will be visible are also advantages of this invention. These **SGS's** are pre-stressed and by varying this pre-stress load the designer can achieve differing structural characteristics (e.g. rigidity, resonance damping etc.) with the same structural elements. **SGS's** can be made collapsible for ease of transportation or storage should collabsability be a desireable feature of the structure being used.

DESCRIPTION OF DRAWINGS

FIG. 1A is a 3 discontinuous strut **HYPERBOLOID SGS** with a circumferential guy arrangement in the top end "plane" and a radial guy arrangement in the bottom end "plane".

FIG. 1B is a 3 discontinuous strut **HYPERBOLOID SGS** with an "internal" guy arrangement.

FIG. 1C is two 3 strut **HYPERBOLOID SGS's** which are nested in a manner that the struts from a "left handed" and a "right handed" one start from the same point in the bottom end "plane" resulting in a triangular set of strut ends in the bottom end "plane" and a hexagonal arrangement in the top end "plane".

FIG.1D is two 3 strut **HYPERBOLOID SGS's** which are nested in a manner that the struts from a "left handed" and a "right handed" one start from points separated by 30 degrees in the bottom and top "planes" resulting in three sets of parallel struts in this embodiment.

FIG. 1E is a 4 discontinuous strut **HYPERBOLOID SGS** with a radial guy configuration in the bottom end "plane" and a circumferential guy configuration in the top end "plane".

FIG. 1F is two 4 strut **HYPERBOLOID SGS's** which are nested such that the struts of a "left handed" one and a "right handed" one start from the same points in the "end-planes".

FIG. 1G is a 6 discontinuous strut **HYPERBOLOID SGS** with radial guy arrangements in the end "planes".

FIG. 1H is three 6 discontinuous strut **HYPERBOLOID SGS's** illustrating an adjacent connection of strut ends.

FIG. 2A is a 6 discontinuous strut **PLANAR SGS** with a radial arrangement of guys in 8 of the 20 faces of the icosahedron. This represents the minimal total length of guy members for the case of the icosahedron with guys on an edge or in the face planes.

FIG.2B is a 6 discontinuous strut **PLANAR SGS** with an "internal" guy arrangement which can further reduce the total length of guy members necessary to provide integrity to the icosahedron.

FIG.3A is a 6 discontinuous strut **HYP-PAR SGS** with a radial arrangement of guys between the elements of the separate hyperbolic paraboloid surfaces and a linear arrangement of guys between elements of the same hyperbolic paraboloid surface.

FIG. 3B is a 10 discontinuous strut **HYP-PAR SGS** with one of the hyperbolic paraboloid surfaces having six elements and the other two having two each. Guy arrangements are the same as **FIG. 3A**.

FIG. 3C is the same as **FIG. 3A** with the struts within each hyperbolic paraboloid surface spread farther apart. Guy arrangements are the same.

FIG. 3D is a 18 discontinuous strut **HYP-PAR SGS** with each of the 3 hyperbolic paraboloid surfaces containing 6 struts. Guy arrangements are the same as **FIG. 3A.**

FIG. 4A is a 6 strut **RADIAL SGS** whose strut ends form the vertices of an octahedron and with a radial arrangement of guys in 4 of the eight faces of this octahedron. This represents the minimal total guy member length to provide sufficient structural integrity for the octahedron.

FIG. 4B is an 8 strut **RADIAL SGS** whose strut ends form the vertices of a cube and with an "internal" arrangement of guy members.

FIG. 4C is a 12 strut **RADIAL SGS** whose strut ends form the vertices of a cuboctahedron and with a radial arrangement of guys in the eight triangular faces of the cuboctahedron. This represents the minimal total guy member length to provide structural integrity to the cuboctahedron.

FIG. 5A is a 4 discontinuous strut **POLYGONAL SGS** whose outer strut ends form the vertices of a tetrahedron with circumferential guys and with the inner guys forming a skewed quadralateral as they connect the inner strut ends.

FIG. 5B is a 6 discontinuous strut **POLYGONAL SGS's** whose outer strut ends become the vertices of an octahedron with radial guys in four of the 8 faces and whose inner strut ends form a three sided prism with circumferential guys for all prism faces.

FIG. 5C is a 8 discontinuous strut **POLYGONAL SGS's** whose outer strut ends form the vertices of a cube with circumferential guys and whose inner strut ends form a four sided prism with circumferential guys for all prism faces.

REFERENCE NUMERALS IN DRAWINGS

All figures are pictures of self guyed structures made with wooden dowels as the compression members and chain as the tension members. The chain is attached to screw eyes inserted into the ends of the dowels.

SUMMARY

This invention, **SELF-GUYED STRUCTURES (SGS's)**, is a series of static structures formed from a plurality of interconnected rigid compression members or struts and flexible tension members or guys (e.g. wire cables, chains or elastic cords). Each strut is in pure compression (i.e. no bending or twisting forces) and each guy is in pure tension. The struts are discontinuous in several embodiments of the invention, intersect at an internal or peripheral point in others, or radiate outwardly from an internal central point in still others. Five categories of strut arrangements are claimed; 1) **HYPERBOLOID SGS's**, 2) **PLANAR SGS's**, 3) **HYP-PAR SGS's**, 4) **RADISL SGS's**, and 5) **POLYGONAL SGS's**.

Three configurations of guy arrangement are claimed for each strut arrangement. The guys can be configured in a 1) circumferential, 2) radial or 3) internal arrangement.

SELF-GUYED STRUCTURES (SGS's) can be utilized as stand-alone modules or modules can be combined by connecting them at any point on a strut or guy in a nested (overlapping) or an adjacently attached configuration to assemble composite **SGS's**.

DESCRIPTION OF INVENTION

This invention is a series of three dimensional, free standing static structures composed of a plurality of compression and tension members The compression members or struts are in pure compression (i.e. no bending or twisting forces) and the tension members or guys (e.g. wire cables, chains or elastic cords) are in pure tension and have both ends attached to the structure itself, not an external anchor point. Five categories of these **SELF-GUYED STRUCTURES (SGS's)** are included in this invention.

1) **HYPERBOLOID SGS's** consist of three or more discontinuous struts arranged on the surface of a hyperboloid of revolution of one sheet. The term discontinuous is used to mean the struts do not touch each other in the construction of the SGS and it means they do not intersect each other either internally or on the periphery of the **SGS**. These structures are enantiomorphic in that struts can have a left handed or a right handed helicity. The lengths of the struts can be equal or of different length and although the length of each strut must span the mid-plane of the hyperboloid of revolution they need not have equal lengths on either side of the mid-plane. The roughly circular arrangement of strut ends on either side of the mid-plane form what are called "end-planes". In the simpler embodiments the strut ends which define "end-planes" are indeed planes and are parallel to the mid-plane of the hyperboloid of revolution. In other embodiments the strut ends need not form a true plane nor do they need to be parallel to the mid-plane. Non-parallel "end-planes" and/or non-equal length struts would allow design options for combinations of structures to exhibit a curvature. However the term "end-planes" will be used to label this part of the **HYPERBALOID SGS**. Three guy configurations are claimed for each of these **HYPERBALOID SGS's** as described below.

2) **PLANAR SGS's** have discontinuous struts and have a minimum of three struts defining a minimum of three (there can be four or more planes) planes which intersect at a common point. These planes can be but dot not necessarily have to be orthogonal to each other. Three guy configurations are claimed for each of these **PLANAR SGS's** as described below.

3) **HY-PAR SGS's** have discontinuous struts which lie on a hyperbolic paraboloid surface. These **SGS's** have a minimum of six struts two in each of three hyperbolic parabaloid surfaces which intersect at a common point. These surfaces can be but need not necessarily be orthogonal to each other. There can be more than 3 hyperbolic paraboloid surfaces. Three guy configurations are claimed for each of these **HY-PAR SGS's** as described below.

4) **RADIAL SGS's** have four or more struts arranged such that compressive forces are radially vectored from an internal central point. The inward strut ends all connect at this internal central point. The internal central point need not be the exact center of the polygon but must be internal to the polygonal faces defined by the outward ends of the struts. Three guy configurations are claimed for each of these **RADIAL SGS's** as described below.

5) **POLYGONAL SGS's** have four or more discontinuous struts arranged in a generally radial (but not precisely radial) configuration. The inward ends of these struts are connected by guys which react the inward radial forces. The inner strut ends form a skewed quadralateral in the tetrahedral version and a three and four sided prism for the octahedral and the cubic **POLYGONAL SGS's** and other configurations for other polygons. Three inner and three outer guy configurations are claimed for the **POLYGONAL SGS's** as described below.

The three guy configurations (and combinations of these three arrangements) which are claimed for each of the above strut configurations are as follows;

1) A circumferential arrangement of guys can be used to connect the strut ends forming the "end-planes" of the **HYPERBOLOID** and the **HY-PAR SGS's** as well as the faces of the polygons formed by the strut ends of the **PLANAR, RADIAL** and **POLYGONAL SGS's** as shown in the figures.

2) A radial arrangement of guys can be used to connect the strut ends forming the "end-planes" of the **HYPERBOLOID** and the **HY-PAR SGS's** as well as the faces of the polygons formed by the strut ends of the **PLANAR, RADIAL** and **POLYGONAL SGS's** as shown in the figures.

3) An internal arrangement of guys can be used to connect the strut ends forming the "end-planes" in combination with the riser guys of the **HYPERBOLOID** and the **HY-PAR SGS's** as well as the faces of the polygons formed by the strut ends of the **PLANAR, RADIAL** and **POLYGONAL SGS's** as shown in the figures. In this internal arrangement the guys are internal to the "end-planes" or faces of these structures.

SELF-GUYED STRUCTURES (SGS's) can be utilized as stand-alone modules or modules can be combined by connecting them at any point on a strut or guy in a nested (overlapping) or an adjacently attached configuration to assemble composite **SGS's**. Parts of one **SGS** can be combined with parts of another (e.g. one plane of the 3 discontinuous strut **PLANAR** with two planes of the **HY-PAR** as well as many other combinations). These **SGS's** can also be combined with traditional structures. In these combinations it is sometimes possible to have a strut and/or a guy that is common to one or more of the combined structures thus allowing the elimination of the extra member(s) and therefore economizing on the total number of separate structural members.

These **SGS's** structures can be made collapsible by a suitable means of elongating selected guys or shortening selected compression members. The degree of pre-stress used to construct each **SGS's** can be varied to achieve certain design goals.

CLAIMS

1) **HYPERBOLOID SGS's** consisting of three or more discontinuous compression members or struts arranged to form elements of the surface of a hyperboloid of revolution of one sheet and with tension members or guys arranged in a circumferential or a radial configuration connecting the strut ends defining the "end-planes" or in combination with the riser guys in an internal configuration. Combinations of these three guy configurations are also claimed. (Except the

three strut circumferentially guyed "end-plane" configuration previously patented by Fuller)

2) **HYPERBOLOID SGS's** as in claim 1) combined with other complete or partial **SGS's** claimed herein or traditional structures in a nested (overlapping) or adjacent configuration wherein the struts or guys may or may not intersect and common elements may or may not be eliminated from the structure for economy reasons.

3) **PLANAR SGS's** consisting of three or more compression members or struts arranged to form elements of the surface of three planes and with tension members or guys arranged in a circumferential or a radial configuration connecting the strut ends defining the polygonal faces or in combination with other guys in an internal configuration. Combinations of these three guy configurations are also claimed. (Except the six discontinuous strut circumferentially guyed structure invented by Kitrick).

4) **PLANAR SGS's** as in claim 3) combined with other complete or partial **SGS's** claimed herein or traditional structures in a nested (overlapping) or adjacent configuration wherein the struts or guys may or may not intersect and common elements may or may not be eliminated from the structure for economy reasons.

5) **HY-PAR SGS's** consisting of six or more discontinuous compression members or struts arranged to form three planes with tension members or guys arranged in a circumferential or a radial configuration connecting the strut ends defining the "end-planes" or in combination with the riser guys in an internal configuration. Combinations of these three guy configurations are also claimed.

6) **HY-PAR SGS's** as in claim 5) combined with other complete or partial **SGS's** claimed herein or traditional structures in a nested (overlapping) or adjacent configuration wherein the struts or guys may or may not intersect and common elements may or may not be eliminated from the structure for economy reasons.

7) **RADIAL SGS's** consisting of four or more compression members or struts arranged to form elements radiating from an internal central point and with tension members or guys arranged in a circumferential or a radial configuration connecting the outer strut ends defining the polygonal faces or in combination with other guys in an internal configuration. Combinations of these three guy configurations are also claimed. Any polygon can be made using this construction method. (Except the six strut circumferentially guyed octahedral structure invented by Kitrick and Gwilliam).

8) **RADIAL SGS's** as in claim 7) combined with other complete or partial **SGS's** claimed herein or traditional structures in a nested (overlapping) or adjacent configuration wherein the struts or guys may or may not intersect and common elements may or may not be eliminated from the structure for economy reasons.

9) **POLYGONAL SGS's** consisting of four compression members or struts arranged somewhat radially (but not precisely radially) . The inward ends of these struts are connected by guys which react the inward radial forces. The inner strut ends form a skewed quadralateral in the tetrahedral version and a three and four sided prism for the octahedral and the cubic **POLYGONAL SGS's** respectively. Higher numbers of struts forming other polygons are also claimed. The inner and outer tension members or guys can be arranged in a circumferential

or a radial configuration connecting the strut ends defining the triangular faces or in combination with other guys in an internal configuration. Combinations of these three guy configurations for both the inner and the outer sets are also claimed.

10) **POLYGONAL SGS's** as in claim 9) combined with other complete or partial **SGS's** claimed herein or traditional structures in a nested (overlapping) or adjacent configuration wherein the struts or guys may or may not intersect and common elements may or may not be eliminated from the structure for economy reasons.

11) **SGS's** with various degrees of pre-stress to achieve design goals.

12) **SGS's** that are collapsible by lengthening selected tension members or shortening selected compression members.

OPERATION – MAIN EMBODIMENT

These are static structures and therefore the description above describes their construction. The operation of collapsing these structures consists of lengthening a selected set of tension elements or shortening a selected set of compression elements. The selected set of elements to be lengthened or shortened depends on the exact configuration of the structure itself.

DESCRIPTION OF OPERATION – ALTERNATIVE EMBODIMENTS

All alternative embodiments and the operation thereof are described above.